
BIO EXPLORER I
(Bionanosatellite Class)
CAL POLY
NASA
SSDL
Free Flyer Planning Meeting
John W. Hines
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FB
ASTRO BIONICS
NASA
Biological & Physical Research
Enterprise
Ames Research Center

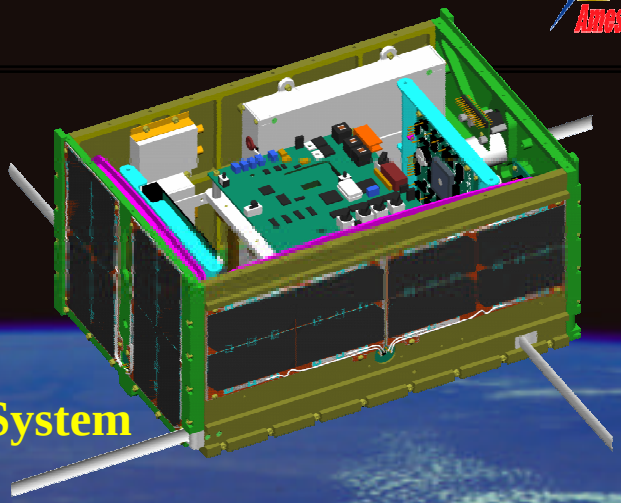
Program/Project Description

- The Bioexplorer I Project is the first of a series of dedicated, nanosatellite free-flyer missions for support of Fundamental Biology research applications.
- Bioexplorer I is a technology feasibility demonstration to evaluate the bionanosatellite platform's capabilities to conduct cell and molecular biological research using model organisms, and to evaluate in-situ technologies suitable for future science missions.
- Bioexplorer I will not have the capability to return science payloads, specimens or samples, and will thus acquire, process, and communicate experimental data to ground.
- Technologies to be evaluated include:
  - Bionanosatellite development, Active and passive attitude control and positioning, communications/control,
  - Biofluidics, optics/photonics (microscopy),, automated sample handling and management
  - Reference spacecraft sensors and actuators
  - Data management, and launch ops.

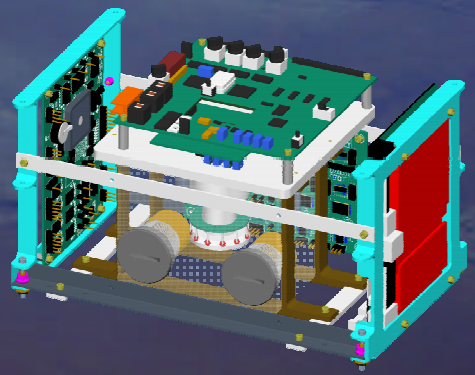
BioExplorer Development Strategy

- 2-3 Flights /year
- 3 payload Classes
  - In situ 1 way (data download, no sample return)
  - In situ + incremental sampling/fixation; return
  - Either/both above, with 1 G control (tether/small centrifuge)
- Focus on Molecular Biology/radiation/Evolution experiments
- Use model organisms, apply molecular bio/genomics/proteomics techniques
  - Yeast
  - Mammalian tissue cells
  - Bacteria
  - C. Elegans
  - Drosophila
  - Avian eggs
- Develop Modular, reconfigurable, in-situ Monitoring and Control technologies
- Explore small satellite programs (NASA/US/Comm'l/Int'l)
  - 10-100Kgm Range with 4size ranges (kgm): [1-10, 10-30, 30-50, 50-100]

BioNano Satellite Overview



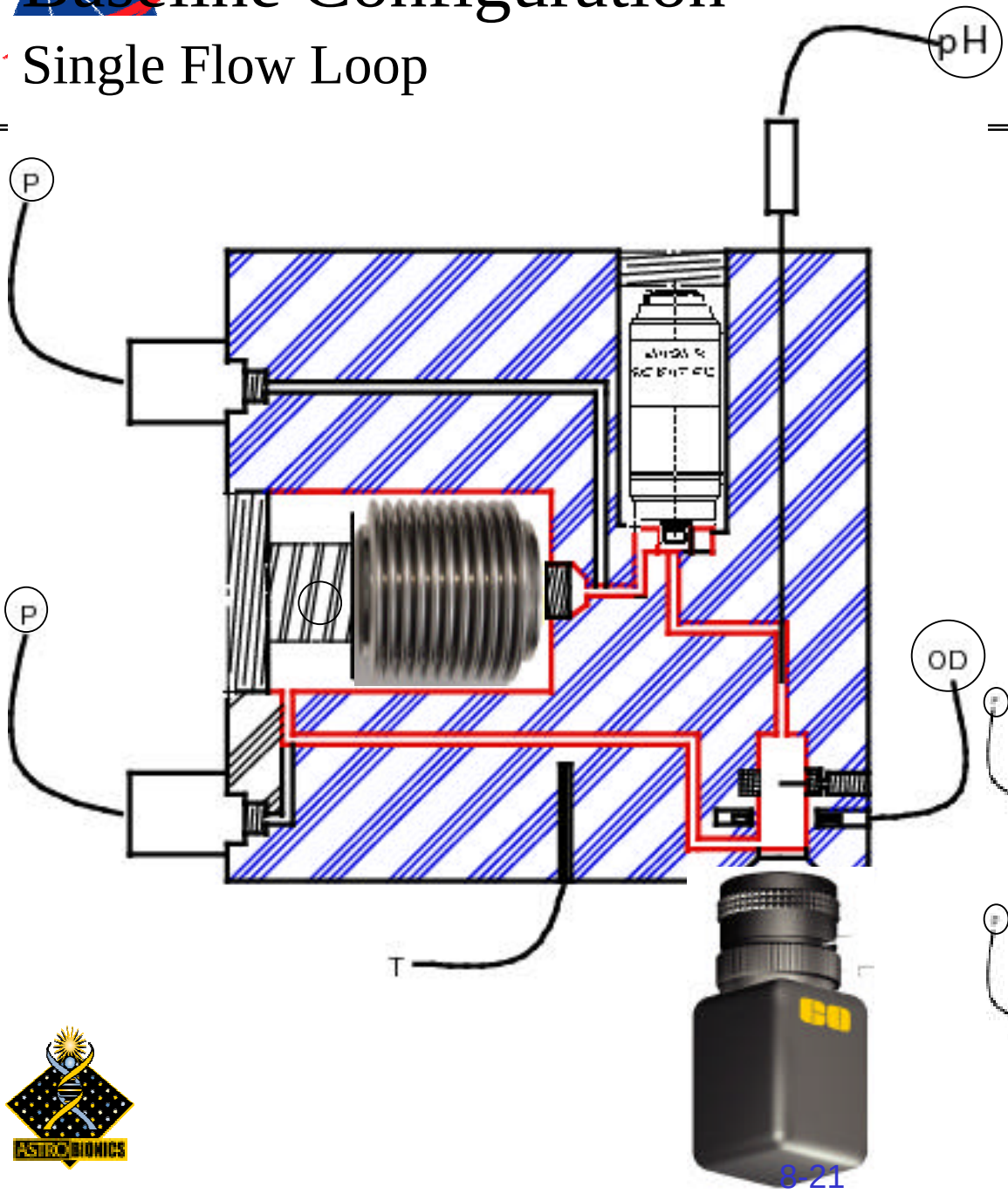
- Satellite Bus Subsystems
  - Chassis Assembly
  - Thermal System
  - Power System
  - Communication System
  - Satellite Control and Data Handling System
  - Stabilization System
  - Data Logger System
  - Software
  - External Camera System
  - Interconnects

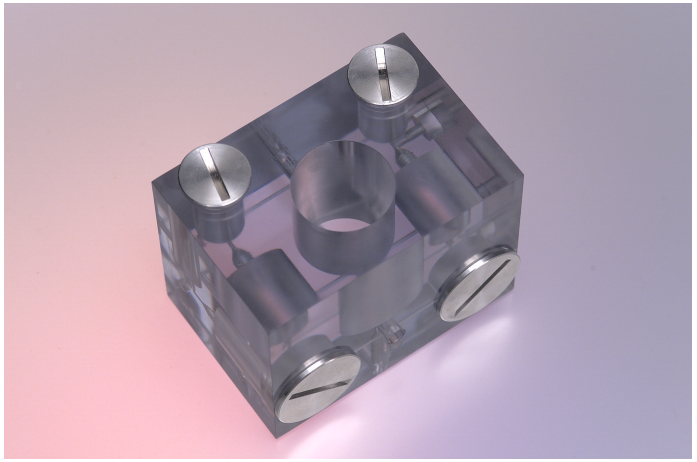


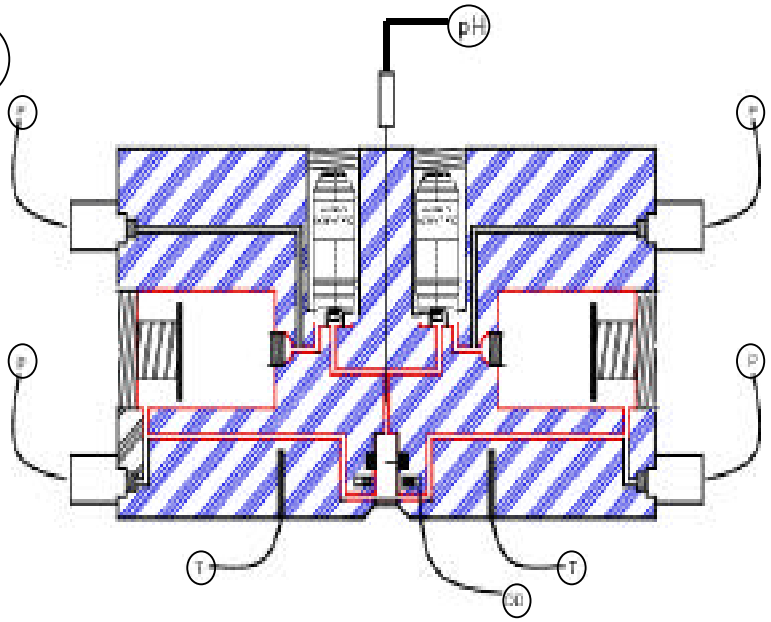
- Experiment System Components
  - Biology System
  - Experiment Electronics System
  - Video System
  - Experiment Software

Baseline Configuration

Single Flow Loop







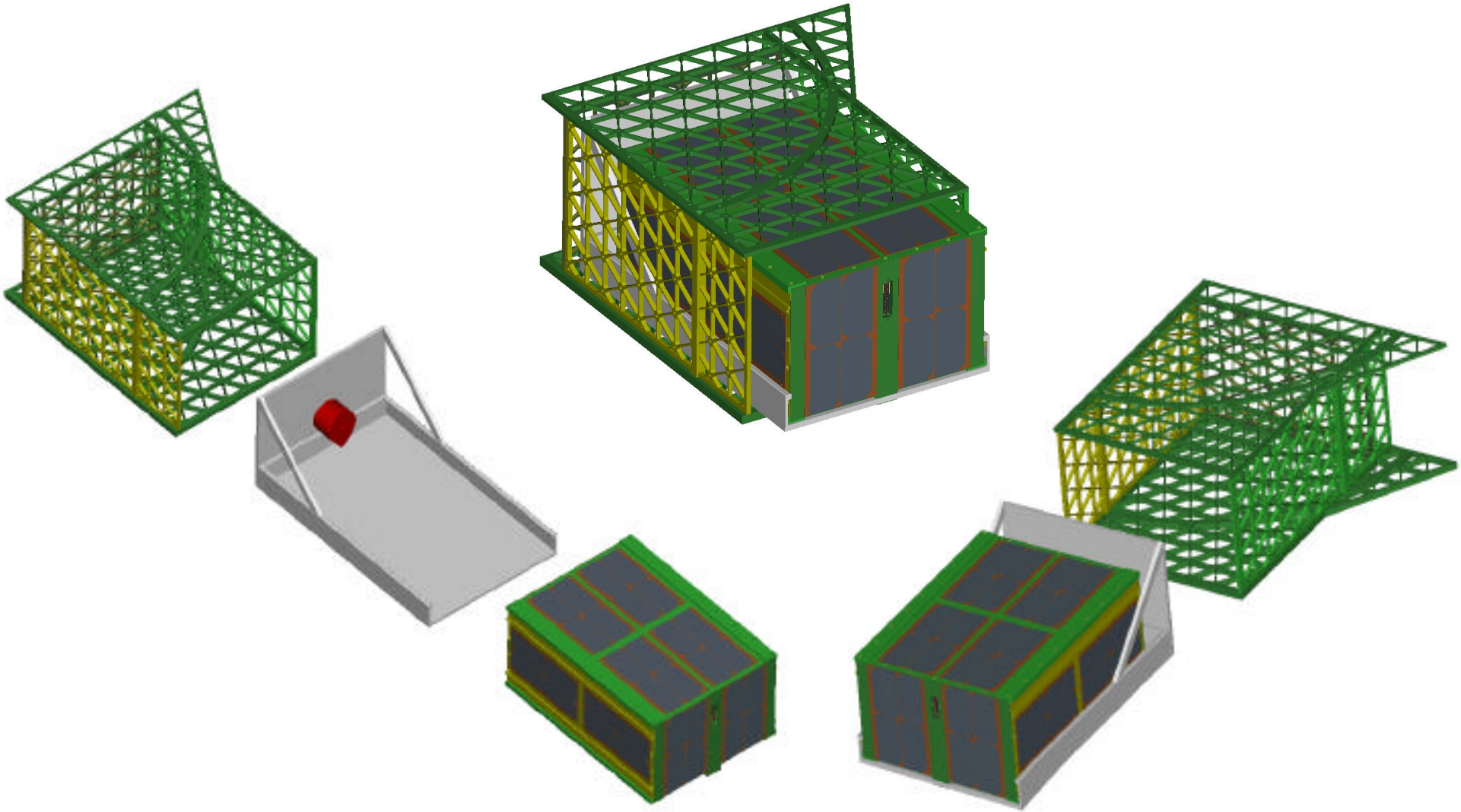
Launch Vehicle Overview

- **Two expendable launch vehicles identified as baseline candidates for the BioExplorer-1 Mission**
- **BioNano Satellite System accommodates multiple launch platform configurations**

Pegasus XL

Russian SS-18 ICBM Rocket

Satellite, Launcher, and Multi-Payload Adapter



Feb 2002
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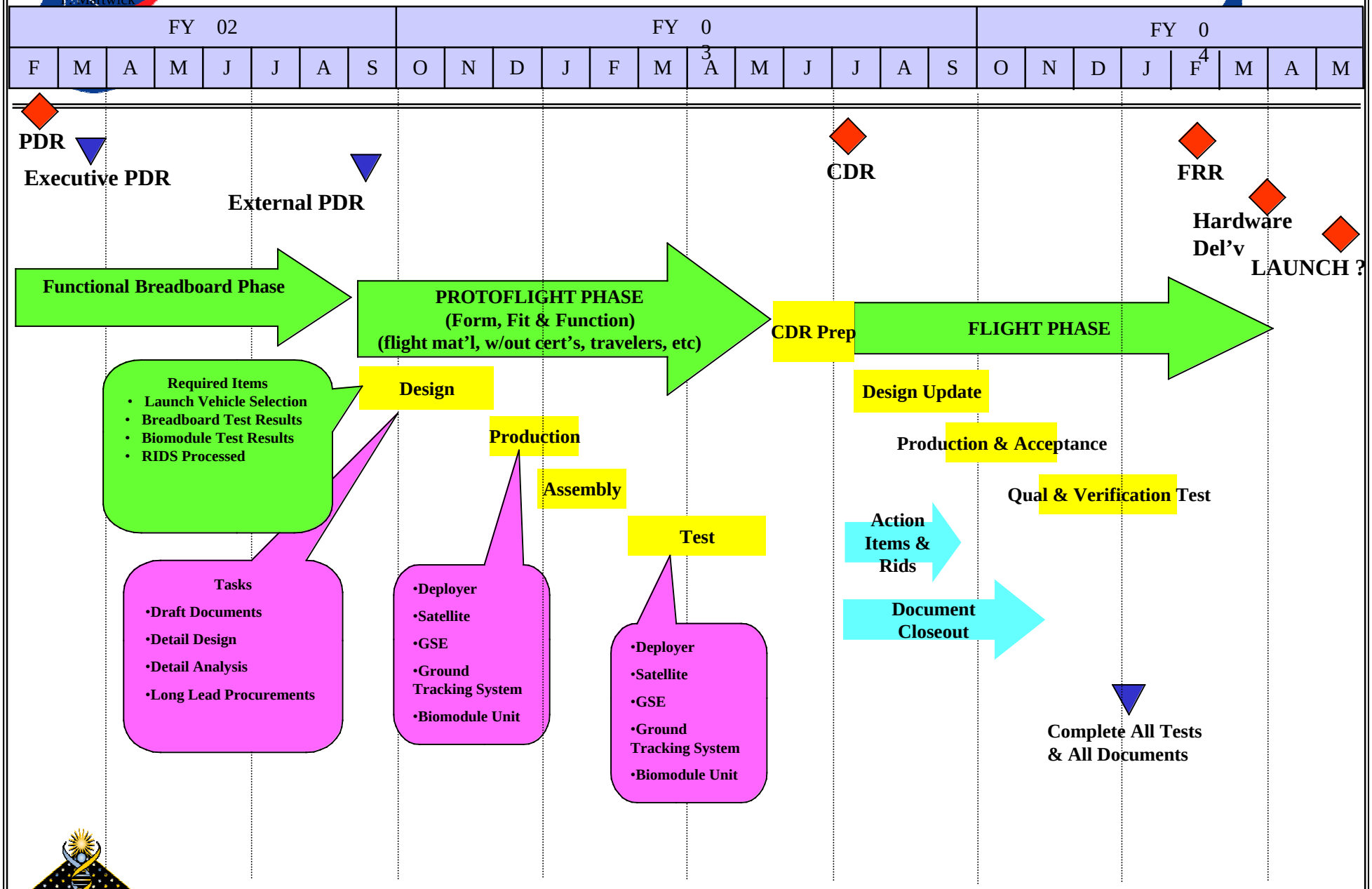
BioNano Satellite Schedule Flow Chart

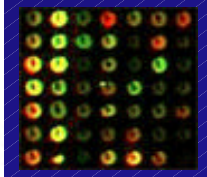
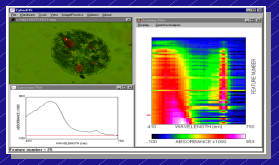


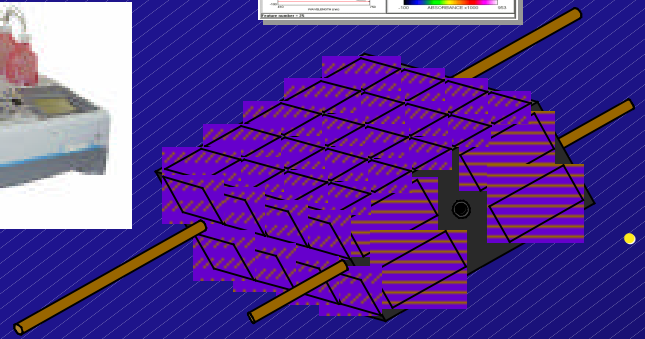

Generations:
A NASA Initiative
BioExplorer and Technology Elements
J. Hines
23 May 2002
3-9

Technology Drivers for Fundamental Biology Research







- **GROW** - Autonomous, multigenerational Habitats

  In-flight systems and modules will permit growth and nurturing of cells, tissues, and higher organisms

- **SENSE** - *in-situ* Biosensors & Sample Management

  Development of biosensors, DNA chips and automated sample management and handling systems will permit in-situ measurement and analysis of biological processes

- **OBSERVE** - Microscopy and Advanced Imaging Systems

  Incorporation of new advances in optical, nano- and information technologies will allow in-situ imaging systems to visualize changes in cell shape and configuration

- **ANALYZE** - Information Systems and Technologies

  Revolutionary developments in bioinformatics, modeling, simulation, and adaptive - autonomous bioanalytical systems will enable rapid conversion of raw data to information/knowledge

- **FLY** - Free Flyer BioNanosatellite Development

  Development and flight demonstration of advanced in-situ biological technologies and platforms

BioExplorer Missions

The intent of this new activity is to develop, demonstrate and utilize small free-flying orbital spacecraft -"BioExplorers" - to support Principal Investigator-led science missions that have been selected through peer review.

Mission	Payload	Science Goals	Species	Technology Requirements
Bioexplorer 1	Test-bed for: - science - technologies - platform	- in-situ growth rates - imaging profiles	-*Saccharomyces cerevisiae*	- cell culture **habitat** - syringe microfluidics - dark field microscopy - biosensors • **fluorescent microscopy?** - **flow Cytometry?**
Bioexplorer 2 -3	- Cell biology studies	- bud scar patterns - cytoskeletal structure - subcellular locations - mutant survival - life cell cycles - radiation effects	-*Saccharomyces cerevisiae* - *c. elegans* - *mammalian cells* - *photosynethetic Plants (euglena)*	- cell culture habitats - advanced imaging: confocal, multi-photon, fluorescent microscopy - flow cytometry - molecular probes
Bioexplorer 4 - 6	- Genetic/Radiation studies	- gene deletion studies - gene expression profiles - radiation effects - aging studies	- *Saccharomyces Cerevisiae* - *c. elegans* - *mammalian cells* - *Plants*	- inflight sample preparation - fix/freeze capabilities - microarray analysis

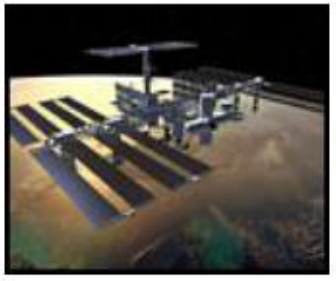
Missions: BioExplorers

Payload Development
- Autonomous, multigenerational habitats
- Advanced in-situ analytical technologies

LEO Free-Flyers
- Technology validation
- Initial multigenerational studies

Arrows denote Initial Bioexplorer-1 emphasis

Space Station/LEO Free-flyers
- Studies of evolution in microgravity
- Payload and technology validation



Bioexplorers: Return Probes
- Small, adaptable-configuration probes
- Microgravity/radiation study, return analysis

Bioexplorers: Free Flyers
- Autonomous, integrated laboratories
- Long-term multigenerational studies

Free-Flyer Satellite Technology Strategy

- ***Define / Incorporate Free Flyer Science Requirements for the OBPR Enterprise***
- ***Assess the State of Technology Development to Address Science Requirements***
- ***Define, Develop, Validate, and Insert into Free Flyer Missions the Key Technologies needed for OBPR Programs and Research Activities***
  - *Implement a phased approach, building incrementally from non-return nanosatellite technology demonstrations to fully operational missions which utilize the full complement of free-flyer platforms, capable of long-duration, beyond low earth orbit deployment, with the possibilities for 1-G controls, advanced orbital maneuvers, and sample return*
  - *Provide the capability to transfer technologies developed for free-flyer to ISS and Shuttle, and utilize those platforms for free-flyer technology demonstration/validation*
- ***Engage the Best Talents within NASA, Universities, and Industry in Technology Definition, Development, and Deployment***
- ***Develop Collaborations with other Technology Sponsors and Providers***
- ***Institute a Technology Development Mechanism / Infrastructure to Ensure Success***

Free-Flyer in-situ Biological Payload Technology Requirements

- *Miniature, in-situ Biological Sensors, Arrays, and Signal Processors*
- *Species-specific Biological Sample Management and Handling Systems*
- *Programmable, in-situ Biofluidics Modules and Processors*
- *Advanced, and Multi-Mode Microscopy, Biophotonics, and Imaging Systems*
- *Long-duration Biospecimen Life Support and Cell Culture Systems*
- *Technologies for in-situ Molecular Biology* ***(Genomics and Proteomics)*** *Research*
- *Miniaturized, Fluorescent Activated Cell Sorters / Cytometers*
- *High-sensitivity, Target-specific BioMolecular Probes, Tags, and Indicators*
- *Autonomous, Robotic, Biospecimen Freezer Modules* ***(Fast, Snap, and Cryogenic)***
- *Advanced Information Technology Tools for Data Interpretation and Control*

Free-Flyer Satellite Platform Technology Requirements

- *Micro-Electro-Mechanical Systems (MEMS) Space Components*
- *Mini-Micro Thrusters/Propulsion/ Attitude Control Systems*
- *High Capacity Miniaturized Flight Power Systems*
- *Radiation Tolerant Instruments, Sensors, and Devices*
- *Tethered Satellite Technologies for 1-G Control and Orbital Maneuvering*
- *Aerocapture, Planetary Landing, and Sample Return Capability*
- *Autonomous, Modular, in-situ Bioanalytical Laboratory Capability*
- *Environmental/Process Monitoring and Control Systems*
- *Smart, Autonomous Command and Data Handling System*
- *Smart, Reconfigurable, Adaptive Spacecraft Materials and Components,*

Lunar Fly By & Return